AIT




# Small Size High Precision Attitude Heading Reference System ARS-8878-R11

# Technical Manual

V1.0

# Small Size High Precision Attitude Heading Reference System

## ARS-8878-R11

## FEATURES

- Nine-axis AHRS sensor intelligent fusion algorithm
- Maximum heading accuracy ⩽0.05° /circle, pitch and roll accuracy ⩽0.05°
- AEC-Q100 certification and manufacturing process
- Accuracy is CNAS traceable
- Wide temperature range: -40℃~ +85℃
- Volume: L31.5*W28*H13 (mm)
  L1.24×W1.1×H0.51 (inch)
- ISO26262 automotive-grade functional safety certification
- 1000Hz raw data output frequency
- Accuracy is CNAS traceable

## APPLICATIONS

- Humanoid robots
- Quadruped robots
- Collaborative robots
- Motion capture
- Low-speed unmanned vehicles
- Observation and aiming equipment

## DESCRIPTION

The ARS-8878-R11 is a high-precision attitude sensor specifically developed for omnidirectional intelligent robots. It integrates AIT's independently developed rapid calibration and anti-interference algorithms. The product undergoes aerospace-grade turntable calibration before leaving the factory, and intelligently eliminates cross-axis errors introduced during installation. It can self-calibrate periodically as needed without requiring return to the factory, ensuring accurate attitude data even in extremely complex environments.

This product features IAP upgrade functionality, allowing firmware updates via software while the device is running. When strong magnetic interference is detected (e.g., high torque output from the robot's own motors), the algorithm intelligently reduces the magnetometer's weight in the data fusion process, increases the weight of the gyroscope and accelerometer, or automatically switches to "six-axis mode." Once the interference lessens or disappears, the magnetometer data is then fused, making it an ideal choice for omnidirectional robots.

## Device performance parameters

**Table 1.**

| | | |
|---|---|---|
| Accelerometer | Measurement Range | ±8g (maximum ±16g） |
| | Noise Density | 80 μg/√Hz |
| | Bandwidth (-3dB) | 290Hz |
| | Zero-Bias Stability (10s Smoothing) | 50 ug |
| | Zero-Bias Stability (ALLAN) | 20 ug |
| | Zero-Point Temperature Drift | ±2 mg |
| Gyroscope | Measurement Range | ±2000°/s |
| | Noise Density | 6 mdps/√Hz |
| | Bandwidth (-3dB) | 370 Hz |
| | Zero-Bias Stability (10s Smoothing) | 10°/h |
| | Zero-Bias Stability (ALLAN) | 2°/h（1σ） |
| | Zero-Point Temperature Drift | ±0.1°/s |
| Magnetometer | Measurement Range | ±2 Gauss |
| | Noise Density | 1.5 mGauss/√Hz |

## Performance Index

**Table 2.**

| | | | |
|---|---|---|---|
| Azimuth Angle | Measurement Range | 0~360° | |
| | Accuracy [1] | Magnetic reference | Non-magnetic reference |
| | | ≤1° (RMS) [2] | ≤0.05°/circle[3] |
| | Resolution | 0.1° | 0.02° |
| | Power-On Repeatability | 0.5° (RMS) | |
| Pitch angle | Measurement Range | ±90° | |
| | Accuracy | Static≤0.05° (1σ) | Low-level dynamics [4] |
| | | | ≤ 0.05° (1σ) |
| | | | Medium-level dynamics [5] |
| | | | ≤ 0.2° (1σ) |
| | | | High-level dynamics [6] |
| | | | ≤ 0.5° (1σ) |
| | Resolution | 0.02° | |
| | Power-on repeatability | 0.05° (RMS) | |
| Roll angle | Measurement Range | ±180° (Pitch angle≤±75°) | |
| | Accuracy | Static≤0.05° (1σ) | Low-level dynamics [4] |
| | | | ≤ 0.05° (1σ) |
| | | | Medium-level dynamics [5] |
| | | | ≤ 0.2° (1σ) |
| | | | High-level dynamics [6] |
| | | | ≤ 0.5° (1σ) |
| | Resolution | 0.02° | |
| | Power-On Repeatability | 0.05° (RMS) | |
| Environments | Baud Rate | 9600~921600 (default 115200) | |
| Output frequency | Raw Data Mode | Max 1000Hz | |
| | Integration Mode | Max 500Hz | |

[1]Accuracy: Root mean square error of the actual angle compared to the sensor's measured angle after multiple measurements (≥16 times) at 25℃.

[2] Magnetic Reference Heading Accuracy: Measured after spatial calibration in a favorable magnetic environment. This product defaults to using a self-developed algorithm to determine the reliability of magnetic data and automatically switches the heading data source.

[3]Non-Magnetic Reference Heading Accuracy: Measured in a laboratory environment by rotating 360° at 100°/s.

[4]Low-Level Dynamics: Motion frequency below 0.2Hz, harmful acceleration below 0.01g.

[5]Medium-Level Dynamics: Motion frequency below 1Hz, harmful acceleration below 0.05g.

[6]High-Level Dynamics: Motion frequency below 5Hz, harmful acceleration below 0.2g.

## Electrical Index

**Table 3.**

| | |
|---|---|
| Power supply | 5-24V DC |
| Operating current | 130mA(Corresponds to the typical 5V value) |
| Operating temperature | -40℃~+85℃ |
| Storage temperature | -55℃~+100℃ |

## Electrical Connect

**Table 4.**

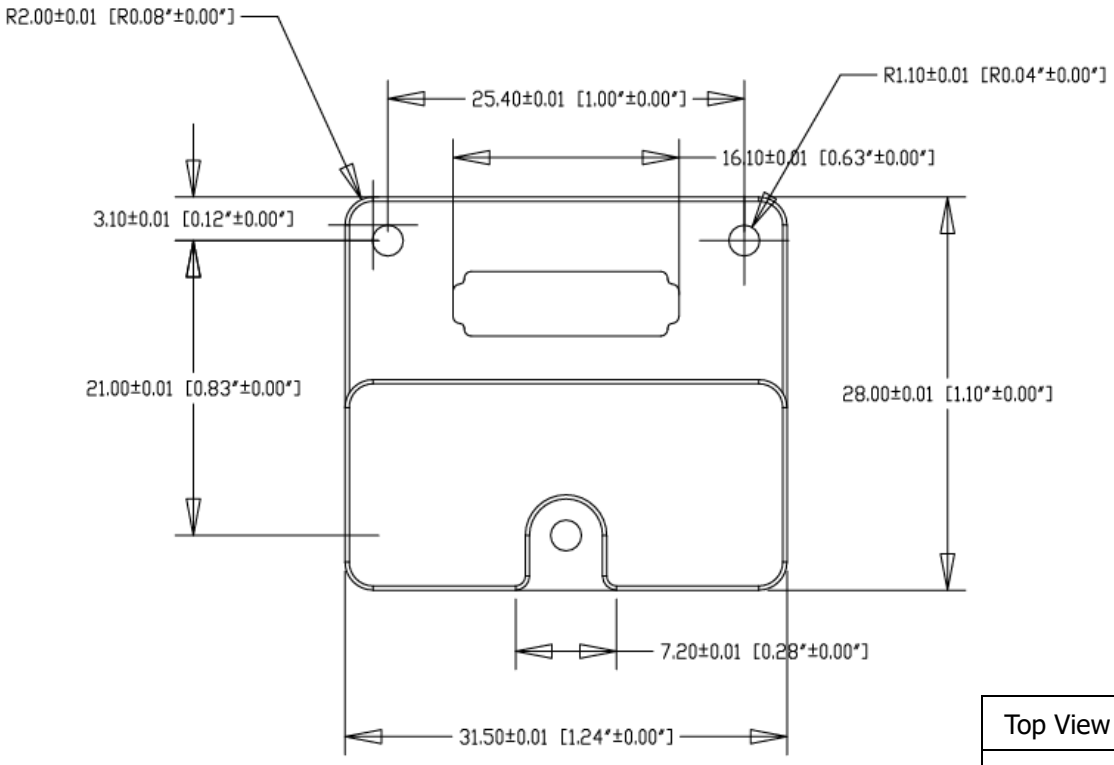
| Pinout | Definition | Interface | Description | Opening Situation |
|---|---|---|---|---|
| 1 | VIN | Power supply | Power Input | OK |
| 2 | GND | Power supply | Power Ground | OK |
| 3 | CAN_H | I/O | CAN High | OK |
| 4 | CAN_L | I/O | CAN Low | OK |
| 5 | 232 TXD | O | 232 Transmit Data | OK |
| 6 | 232 RTS | O | 232 Request Transmit | |
| 7 | 232 RXD | I | 232 Receive Data | OK |
| 8 | 232 CTS | I | 232 Clear Transmit | |
| 9 | SYNC IN1 | I | Synchronization Input 1 | |
| 10 | SYNC IN2 | I | Synchronization Input 2 | |
| 11 | GNSS TXD | O | Transmit Data in GNSS Mode | |
| 12 | GNSS RXD | I | Receive Data in GNSS Mode | |
| 13 | SYNC OUT | O | Synchronization Output | |
| 14 | GND | Power supply | Power Ground | OK |
| 15 | TTL TXD | O | TTL Output | OK |

| | | | | |
|---|---|---|---|---|
| 16 | TTL RXD | I | TTL Input | OK |

This product's communication interface supports CAN, RS232, and TTL. Currently, only the pins marked "OK" are open for use; the remaining pins will be gradually made available in future updates.

## Product Package Size

Product size: L31.5*W28*H13 (mm) The length and width may have an error of ±1mm, please refer to the actual product.



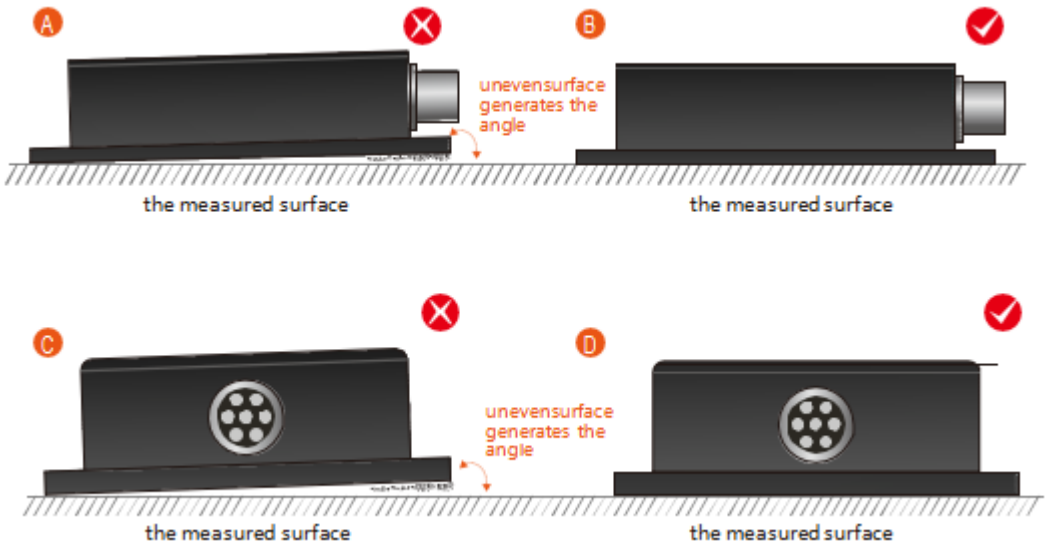

| | |
|---|---|
| Top View | Side View |
| Side View | Unit: mm (inch) |

Figure 2. Outline Dimensions

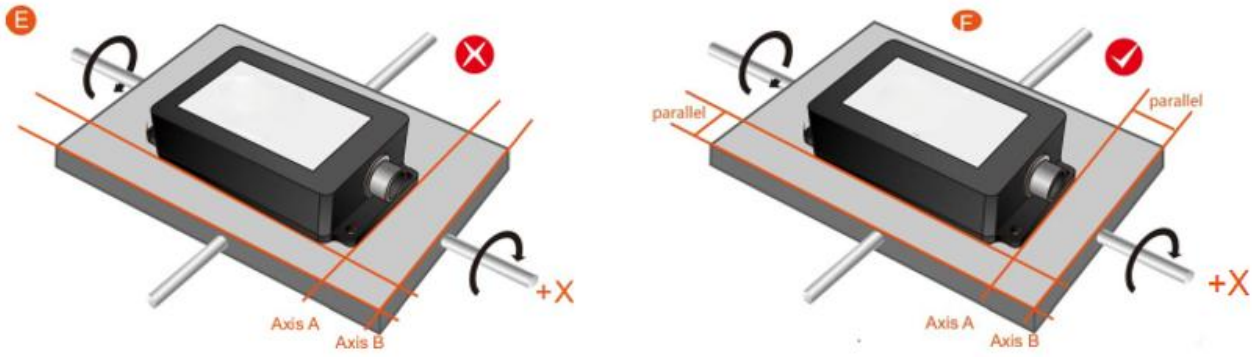
## Installation

The correct installation method can avoid measurement errors. When installing the sensor, please do the following:

First of all, make sure that the sensor mounting surface is completely close to the measured surface, and the measured surface should be as level as possible. There should be no included angles as shown in Figure A and Figure C. The correct installation method is shown in Figure B and Figure D.




Secondly, the bottom line of the sensor and the axis of the measured object cannot have an angle as shown in Figure E, and the bottom line of the sensor should be kept parallel or orthogonal to the axis of rotation of the measured object during installation. This product can be installed horizontally or vertically (vertical installation needs to be customized), and the correct installation method is shown in Figure F.




Finally, the mounting surface of the sensor and the surface to be measured must be tightly fixed, smooth in contact, and stable in rotation, and measurement errors due to acceleration and vibration must be avoided.

Note:It should be kept away from strong magnetic field materials such as magnets, iron, nickel, etc. to avoid irreversible damage to the product's magnetic field sensitive components.

It should be far away from electric motors, wires, capacitors, inductors and other materials that can easily generate magnetic fields due to electric currents, so as to avoid changes in the electromagnetic field of these parts due to energisation, which will affect the heading accuracy of the sensors during continuous measurements.
Keep away from moving iron parts, such as mechanical arms, flywheels, engines, etc., to avoid the magnetic field changes caused by the movement of its ferromagnetic parts, which will affect the heading accuracy of the sensor.

## Calibration

The calibration uses a rapid calibration method, with the following steps:
1. Open the serial port and set it to HEX transmit and HEX receive, and put the sensor in acknowledgment mode.
2. Place the sensor with a pitch angle of 0°, a roll angle of 0°, and a yaw angle pointing due north. Use this direction as the reference direction. If you don't know where due north is, you can use any direction as the reference direction. Keep the sensor stationary and send the "Start Calibration" command to initiate calibration mode. After calibration mode is initiated, a calibration count will be automatically sent. This value will iterate continuously during the motion calibration process and converge and begin to increase when stationary. If the sensor remains stationary, the calibration count will also automatically increase over time, and the calibration result will be unreliable.
3. Slowly rotate the sensor one circle around the X-axis.
4. Slowly rotate the sensor one circle around the Y-axis.
5. Slowly rotate the sensor one circle around the Z-axis. The rotation steps are now complete.
6. Place the sensor stationary and wait for the calibration count in the returned command to be greater than or equal to 0x0A. The calibration is considered complete.
7. Send the "End Calibration" command. Calibration is complete.

**Mechanical Characteristic**

| | |
|---|---|
| Connector | Phoenix Contact (1373828) |
| House Material | Magnesium-Aluminum Alloy Anodized |
| Weight | 15g±1g |
| Installation | 3 M2 Copper Bolts |